

Attainment Targets Biology

Domain B: Structures of ecosystems, organisms, and cells

B1 Subdomain: Structures of ecosystems

The candidate can indicate and explain the significance of and interaction between abiotic and biotic factors which determine the diversity between and within ecosystems.

Required prior knowledge of:

Classification of organisms, binomial nomenclature.

The candidate can:

- describe the relations in an ecosystem.
- explain that the differences between and the diversity in ecosystems are created by differences in abiotic and biotic factors.
- explain that abiotic and biotic factors determine the possibility of growth, development, and the functioning of organisms, and in particular:
 - o tolerance limits, tolerance curve;
 - o limiting factors;
 - o micro climate.
- in a described ecosystem name the different relationships between species and individuals of a species, in particular:
 - o competition;
 - o feeding relationship, predation;
 - o symbiosis: mutualism, commensalism, parasitism;
 - o reproductive relationship.
- use the concept of niche of a certain species in a described ecosystem.
- use the concept of habitat of a certain species in a described ecosystem.

Domain C: Life cycle and genetic information

C1 Subdomain: Heredity

The candidate can explain heredity on the level of organisms by describing genetic processes on lower levels of organisation and can discuss human intervention in genetic processes.

Required prior knowledge of:

Genes, chromosomes, sexual and asexual reproduction. Differences between mitosis-meiosis, cell specialisation by turning parts of chromosomes on and off.

The candidate can:

- make the link between DNA, allele, gene, gene product, chromosome, and genotype.
- explain how the genotype and environmental factors produce the phenotype.
- determine from data whether certain changes of the phenotype are caused by the genotype or the environment.

- explain why sexual reproduction, as opposed to asexual reproduction, produces new combinations of genetic information.
- explain in which way the division of genetic material among the gametes is established.
- indicate that humans, using old and new techniques, are intervening in genetic information with the aim of enhancing desired properties, also in humans themselves:
 - o cloning;
 - o use of mutation;
 - o use of recombination;
 - o DNA techniques;
 - o cell fusion;
 - o selection, plant and animal breeding, genetic modification.
- predict the results of mono- and dihybrid crosses, using probability calculations among other things, in particular:
 - o locus;
 - o dominant and recessive alleles, co-dominance;
 - o intermediate phenotype;
 - o autosomal and X-chromosomal genes;
 - o regrouping of chromosomes, paired genes, crossing over (no localisation of genes)¹.
- apply the knowledge mentioned in the previous attainment target to pedigree research.
- interpret data from chromosome research, as used in heredity advice and pre- and postnatal diagnostics in humans, and indicate the significance of DNA research in this.
- indicate that genetic and environmental factors influence disease emergence.

Domain D: Metabolism

D1 Subdomain: Flows of energy and cycles

The candidate can describe flows of energy and substance cycles in an ecosystem and can indicate which factors affect this and what the causes and results of a disturbance are.

Required prior knowledge of:

Classification of organisms, food chain, food web, human influence on the environment.

Photosynthesis, aerobic and anaerobic dissimilation.

The candidate can:

- explain that the sun is the most important source of energy for life on earth.
- graphically represent the energy content and the biomass of the trophic levels of a food chain.
- indicate why in a link of the food chain not all the biomass produced or absorbed is stored.
- indicate that a cycle can be interpreted as a body of supplies and flows of matter.
- indicate which production of organic substances takes place in an ecosystem using the concepts: gross primary production, nett primary production, productivity.
- indicate that cycles in an ecosystem are interrupted or disturbed by, among other things:
 - o separate locations of production and consumption;

¹ The phenomenon of crossing-over must be known as such. Students do not have to be able to make calculations with it.

- use of fossil fuels.
- in a description or image of an ecosystem, list examples of organisms that belong to:
 - producers, consumers, and reducers, respectively;
 - autotrophic and heterotrophic organisms, respectively.
- apply the concept of 'limiting factors' to different specific situations.
- explain the role of producers, consumers, and reducers in the carbon and the nitrogen cycles using diagrams of these cycles, specifically:
 - photosynthesis and dissimilation;
 - conversion of glucose into other organic substances;
 - production of nitrogen-containing organic substances;
 - reduction of organic substances into inorganic substances.
- indicate the role of microorganisms in the carbon cycle and the nitrogen cycle.
- indicate what is meant by biological degradability.
- indicate the effects of human activity on the carbon cycle and the nitrogen cycle.
- indicate the differences between ecological and non-ecological food production, in particular:
 - differences in the use of fertilisers and pesticides;
 - use of biotechnology;
 - sustainable food production.

D3 Subdomain: Human metabolism

The candidate can indicate how human organs, tissues, and cells are involved in the uptake, processing, transport, storage, and secretion of substances, has insight into the molecular processes that play a role in this, and can discuss the factors that might influence this.

Required prior knowledge of:

Human anatomy and physiology, function of nutrients. Shape and function of organelles

The candidate can:

- indicate which organs and/or tissues humans have for the absorption of substances, for transport, for making substances suitable for transport, for removing excess and harmful metabolic products, and for storage of substances.
- in images recognise organs and different types of tissues that are involved in digestion and indicate the function of these organs and tissues.
- using anatomical information, indicate which treatment food undergoes in the digestive tract, in particular:
 - mechanical treatment and digestion;
 - removal of indigestible substances and waste products;
 - absorption of nutrients from the digestive tract into the blood and/or lymph;
 - emulsification.
- indicate which nutrients can be resorbed by humans, and in particular:
 - resorption of water, of water-soluble substances, of lipid-soluble substances, and the role of micelles in this.
- indicate that recreational drugs, medicines, and toxins can also be resorbed.

- use the following chemical concepts in a biological situation:
 - proteins, essential amino acids;
 - carbohydrates;
 - oils, fats, essential fatty acids, saturated and unsaturated fatty acids;
 - salts;
 - vitamins.
- using anatomical information, indicate the relationship between the structure and the function of the heart and the blood and lymph vessels and how they work.
- describe the components of blood and interpret information about the role that red bone marrow plays in the formation of red blood cells.
- indicate functions of blood, and in particular:
 - transport of O₂, CO₂, nutrients, waste products, and hormones;
 - equilibrium reactions;
 - buffer function;
 - blood clotting.
- list regulation mechanisms for the composition of blood and for the circulatory system, and in particular:
 - pH;
 - pCO₂;
 - glucose level;
 - osmotic value.
- indicate how and where the uptake, transport, and release of CO₂ and O₂ take place and indicate the role of haemoglobin in this.
- indicate which processes in the capillaries create tissue fluid and which processes play a role in the exchange of substances between cells and their environment, in particular:
 - diffusion, including osmosis;
 - active transport;
 - blood pressure.
- indicate the relationship between tissue fluid and lymph.
- indicate the function of the airways and lungs and the operation of the muscles of respiration using information given about their structure.
- indicate how pCO₂, pO₂, and pH influence the regulation of ventilation via the respiratory centre in the brain stem.
- using anatomical information, indicate the link between the structure and function of the kidneys and how they work, in particular:
 - ultrafiltration;
 - reabsorption;
 - blood pressure;
 - diffusion, including osmosis;
 - active transport.
- list the functions of the liver, and in particular:
 - glycogen storage;
 - gluconeogenesis;
 - production of cholesterol;

- formation of blood proteins;
- formation of gall: bile acids, bile pigments;
- excretion of products in gall;
- transamination and deamination;
- detoxification.
- indicate the relationship between how various organs function in relation to human metabolism:
 - organs involved in digestion;
 - liver;
 - respiratory system;
 - kidneys;
 - cardiovascular system.

D4 Subdomain: Cell processes

The candidate can distinguish different cell processes, among which assimilation and dissimilation processes, and relate them to different organisational levels and indicate which factors affect them.

Required prior knowledge of:

Structure of plants, functions of plant tissues, combustion, photosynthesis. Form and function of cell organelles, enzyme function.

The candidate can:

- indicate that metabolic processes are taking place in the cells of an organism.
- use the concepts of dissimilation and assimilation.
- indicate that different types of dissimilation of organic substances exist that release energy.
- give the reaction equation of the aerobic dissimilation of glucose:

$$C_6H_{12}O_6 + 6 H_2O + 6O_2 \rightarrow 6CO_2 + 12 H_2O + E.$$
- indicate how the aerobic dissimilation of glucose takes place:
 - first phase in the cytoplasm with limited ATP-production (glycolysis);
 - continuation in the mitochondria (citric acid cycle):
 - energy being released is stored in ATP or is released as heat;
 - oxidative phosphorylation: $ADP + P_i + E \rightarrow ATP$ (electron transport chain; proton pump; ATP synthase).
- indicate that the ATP production per glucose molecule is less in anaerobic dissimilation than in aerobic assimilation because high-energy substances, lactic acid, or alcohol (ethanol) are formed as end-products.
- indicate that ATP is the source of energy for the synthesis of substances, movement, and active transport of substances, among other things.
- indicate that, in plants, energy is stored during the composition (assimilation) of organic substances.
- indicate that energy for photosynthesis comes from light and is stored in ATP, among other things.

- give the reaction equation of photosynthesis and indicate the function of chloroplasts in this:

$$6\text{CO}_2 + 12\text{H}_2\text{O} + \text{E} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{H}_2\text{O} + 6\text{O}_2.$$
- indicate how photosynthesis takes place:
 - during light reactions water splitting through solar energy, production of ATP and hydrogen bonded to the coenzyme NADP;
 - during dark reactions glucose production from a supply of carbon compounds and carbon dioxide using products from the light reaction.
- indicate that in all cells continued assimilation takes place in which:
 - glucose is the raw material for the assembly of other carbohydrates and of fats;
 - amino acids are the building blocks for proteins;
 - in plants amino acids and nucleotides are formed from glucose as well as inorganic nitrogen and sulphur compounds that have been absorbed from the soil.

D5 Subdomain: Protein synthesis and biotechnology

The candidate can explain how DNA and RNA are involved in the synthesis of proteins, has insight into the operation of enzymes and factors that affect enzyme operation and can make a link between these processes and heredity.

Required prior knowledge:

Cell organelles and their functions.

The candidate can:

- indicate which functions proteins have inside and outside the organism's cells:
 - enzymes;
 - structural proteins;
 - transport proteins;
 - receptor proteins;
 - plasma proteins;
 - antibodies.
- indicate that DNA and RNA are nucleic acids: polyesters of phosphoric acid and (deoxy)ribose plus nucleobases.
- interpret a given image of the molecular structure of DNA and RNA:
 - helix structure;
 - DNA: nucleotides consisting of deoxyribose, phosphate, and the nucleobases: adenine (A), guanine (G), cytosine (C), thymine (T).
 - base pairing;
 - RNA: nucleotides with ribose instead of deoxyribose and uracil (U) instead of thymine (T).
- describe the synthesis of proteins and the role of DNA (introns, exons), pre mRNA, mRNA, tRNA, ribosomes, endoplasmic reticulum, and Golgi apparatus in this, for which a diagram of this synthesis can be used:
 - replication;
 - transcription;

- translation;
- splicing;
- phases of the cell cycle in which the above-mentioned processes take place;
- explain what DNA mutations are and clarify how mutations are caused.
- explain that cell differentiation and cell specialisation arise because certain genes are turned on or off.
- indicate that in different compartments of the cell, specific enzymes are located that enable certain metabolic processes, and in particular:
 - in the core, enzymes for the (re)production and repair of DNA and RNA;
 - in the ribosomes free in the cytoplasm and bound to the endoplasmic reticulum, enzymes for the pairing of amino acid molecules;
 - in the endoplasmic reticulum and the Golgi apparatus, enzymes for the processing of proteins.
- indicate that proteins and nucleic acids show a primary, secondary, tertiary, and sometimes quaternary molecular structure and indicate the significance of these molecular structures.
- indicate that pH and temperature can affect the molecular structure of proteins and nucleic acids.
- describe what enzymes are:
 - many active enzymes consist of a protein and a vitamin or coenzyme.
- explain that with a limited number of amino acids a large variety of proteins can be created.
- indicate the significance of the fact that cells release enzymes in their inactive forms in a variety of places and that these enzymes only become active when another component or substance reaches them, in particular:
 - digestive and clotting enzymes.
- list the conditions under which an enzyme catalyses a chemical reaction with a substrate:
 - substrate specific;
 - reaction specific;
 - activity depends on temperature and pH (optimum curves).
- indicate what the operation of enzymes is founded on:
 - enzyme binding to substrate, activator, and/or inhibitor;
 - change in the spatial structure of the enzyme molecules;
 - change in the activity;
 - certain medications or toxins also function as activators or inhibitors.

Domain E: Dynamics and homeostasis

E2 Subdomain: Creation and maintenance of diversity

The candidate can indicate the significance of diversity in a population, including on gene level, and reproduce opinions on its formation.

Required prior knowledge of:

Definition of species, division plant and animal kingdom. DNA and heredity, genotype and phenotype, mutation.

The candidate can:

- indicate the significance of diversity in a population for the preservation of the population.
- explain the role of selection with regard to the diversity of a population remaining constant or changing.
- calculate allele frequencies in a gene pool using the Hardy-Weinberg law.
- indicate that, with the theory of evolution, people attempt to explain the origin of different life forms using the following principles:
 - mutations cause diversity within populations;
 - more offspring are produced than the carrying capacity;
 - the individuals that, through natural selection, are best adapted to the environment have the greatest chance of survival;
 - because of this allele frequencies shift.
- indicate that, using the theory of evolution, people attempt to explain the origin of certain life forms by:
 - going back in time, as it were, through the study of fossils;
 - determine the relationship between 'corresponding' parts of different organisms through comparative morphological and developmental biological research and through comparison of DNA: homology, analogy.
- reflect past and current views and ideas on the origin of life and life forms, in particular:
 - spontaneous generation;
 - creation;
 - evolution.
- indicate that classification is possible based on common ancestry, in particular:
 - evolutionary relationships (structure and composition DNA and chromosomes).

E4 Subdomain: Homeostasis in humans

The candidate can explain how senses, muscles and glands, the nervous system, and the hormone system are involved in the functioning of the body –adapted to the environment– and make connections between the different levels of organisation.

Required prior knowledge:

Shape and function of muscles and glands, senses, and the nervous system. Structure and function of the cell membrane with receptor proteins, transport through the membrane, osmosis, diffusion, active transport.

The candidate can:

- apply the principles of a control loop to different systems of the human body.
- schematically represent a control loop and describe the processes taking place in a control loop, in particular:
 - registration in the central nervous system of a change in the internal or external environment through receptors;
 - comparison of this registration to an internal norm;
 - a difference can lead to signals being sent to effectors, causing them to respond;

- the reaction can lead to a restoration of the difference between the registration and the norm or a reaction can be triggered in another control loop, bringing about a new equilibrium.
- describe the relationship between the nervous system and the endocrine system.
- indicate that the regulation of various bodily processes is susceptible to moods and emotions, which has implications for homeostasis and – sometimes – for health.
- indicate that some receptors are sensitive to changes in muscle tone, to temperature, and to the composition of blood.
- explain that higher concentrations of various circulating hormones affect the further release of hormones by the pituitary gland (feedback mechanisms).
- describe how senses, the nervous system, and muscles work and explain their relationship, for which information given about their construction can be used.
- describe the function of senses in humans using the concepts of adequate stimulus and sensory threshold.
- describe how the eyes work and explain how the following are established:
 - accommodation;
 - colour and contrast perception;
 - pupillary light reflex;
 - depth perception;
 - for which an image of the structure of the eyes can be used.
- describe the organisation of the nervous system using an image of its macroscopic structure.
- indicate which processes on a cellular and molecular level lie at the basis of the conversion of stimuli into action potentials.
- explain how action potentials are generated, how they are transmitted, and how this transmission is affected, for which an image of the structure of neurons can be used, in particular:
 - generation in receptors when adequate stimuli exceed a certain sensory threshold;
 - transmission via neurotransmitters: inhibiting and exciting;
 - influence by alcohol, drugs, and medication.
- indicate how action potentials can lead to muscle contraction.
- explain the principle of a reflex and its function in posture, movement, and protection.
- using images of the macroscopic, microscopic, and submicroscopic structure of striated muscles, describe the relationship between their structure and function, in particular:
 - contraction mechanism of filaments;
 - motor units.
- apply given information about the function of specific hormones, the hormone glands that produce them, and their target organs in described situations.
- explain that the characteristics of hormones are decisive in establishing a reaction, in particular:
 - hormones are released into the bloodstream;
 - the hormone concentration is decisive for the degree of reaction by the target organs;
 - hormones have a specific molecular structure that is only recognised by receptor molecules on or in cells of target organs.

- using given information, describe the function of the hypothalamus pituitary gland system and explain how the hypothalamus inhibits or stimulates the pituitary gland through hormones.
- explain how the glucose level in the blood is controlled along the principle of a control loop with the help of insulin and glucagon.
- indicate what the effect of an increased adrenaline release is and what function this effect has.

E5 Subdomain: Protection of the internal environment

The candidate can explain how the skin and the immune system contribute to maintaining the dynamic equilibrium in the internal environment.

Required prior knowledge of:

Structure and function of the skin, bacteria, and viruses. Characteristics of a virus, functions of the membrane.

The candidate can:

- explain the functions of the skin using an image of its structure, in particular:
 - o help maintain a constant internal environment;
 - o controlling body temperature;
 - o storage of fat;
 - o protection by pigment, among other things;
 - o production of vitamin D.
- list the organs involved in the immune response and describe their functions in this, in particular:
 - o skin and mucus membranes;
 - o thymus;
 - o lymph nodes;
 - o spleen;
 - o bone marrow.
- using an image, describe the function of stem cells and the diverse leucocytes, among other things.
- explain what the functions of the cell membrane are in:
 - o maintaining constant cell conditions;
 - o receiving signals and controlling cell processes through receptors, among other things.
- explain that the cell membrane shields the cell from its environment so that concentration differences between cell and environment are made possible.
- explain in what ways the exchange of substances between the cell and its environment are established and indicate the differences between these processes, in particular:
 - o immunoglobulins;
 - o memory cells.
- explain that antibodies are formed against antigens, in particular:
 - o foreign cells and substances;

- bacteria;
 - viruses.
- explain that red blood cells are also carriers of antigens that can be distinguished as blood types and that this is taken into account in blood transfusions, in particular;
 - ABO system;
 - Rhesus factor.
- explain that antigens play a role in organ transplants and describe the consequences of this, in particular:
 - MHC-I and MHC-II
- explain why the presence of antibodies is an indicator for infection, in particular:
 - seropositivity.
- explain the difference between active and passive immunisation and list their applications, in particular:
 - vaccines; serums.